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(54) **Wound dressing containing aldehyde-modified regenerated polysaccharide**

(57) The present invention is directed to wound dressings that include a substrate for contacting and/or covering a wound, where the substrate includes a wound-contacting surface, and which substrate contains or is fabricated at least in part from a biocompatible, aldehyde-modified, regenerated polysaccharide,

preferably a biodegradable polysaccharide, and to methods of providing coverage and protection of a wound, which method includes applying to a wound the wound dressing of the present invention.

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**Description****FIELD OF THE INVENTION**

5 [0001] The present invention relates to wound dressings containing or fabricated in part from an aldehyde-modified, regenerated polysaccharide, e.g. a biodegradable aldehyde-modified, regenerated cellulose, and to methods of providing coverage and protection to a wound using such wound dressings.

**BACKGROUND OF THE INVENTION**

10 [0002] The control of bleeding is essential and critical in surgical procedures to minimize blood loss, to reduce post-surgical complications, and to shorten the duration of the surgery in the operating room. Oxidized regenerated cellulose, as described herein below and commonly referred to as ORC, due to its biodegradability, bactericidal, and hemostatic properties, has long been used as a hemostatic wound dressing in a variety of surgical procedures, including neuro-  
 15 surgery, abdominal surgery, cardiovascular surgery, thoracic surgery, head and neck surgery, pelvic surgery, and skin and subcutaneous tissue procedures. ORC, as recognized heretofore by those skilled in the art of wound dressings, is carboxylic-oxidized, regenerated cellulose comprising reactive carboxylic acid groups. In other words, the oxidized cellulose is carboxyl-modified to contain a certain amount of carboxylic acid moieties. Examples of hemostatic ORC absorbable hemostats commercially available include Surgicel® absorbable hemostat, a knitted fabric of ORC; Surgicel  
 20 Nu-Knit® absorbable hemostat, a dense ORC fabric; and Surgicel® Fibrillar absorbable hemostat; all available from Johnson & Johnson Wound Management Worldwide, a division of Ethicon, Inc., Somerville, New Jersey, a Johnson & Johnson Company. Other examples of commercial absorbable hemostats containing carboxyl-oxidized cellulose include Oxycel® absorbable cellulose surgical wound dressing, available from Becton Dickinson, Morris Plains, New Jersey.

25 [0003] Conventional oxidized cellulose (OC) and oxidized regenerated cellulose (ORC) hemostats noted above are knitted, woven or non-woven fabrics comprising carboxylic acid groups, as noted above, in amounts effective to provide them with anti-microbial properties. However, the acid-based ORC and OC, due to their acidic pH, also rapidly denatures acid sensitive and hemostatic proteins, including thrombin or fibrinogen, on contact. Thus it is most problematic and has not been suggested in the art to use the OC or ORC as a carrier for acid-sensitive species, such as thrombin  
 30 and fibrinogen, as well as other acid-sensitive biologics and pharmaceutical agents.

[0004] Cellulose can undergo many modifications in oxidizing media and, accordingly, the properties of oxidized cellulose, generally referred to as oxycellulose, vary widely depending on the oxidation agents used. Oxidation of the secondary alcohol groups of cellulose with periodic acid or its salts to form a aldehyde-modified cellulose has been disclosed in the prior art as a means of characterizing the chemical structure of mono-, oligo- and polysaccharide-  
 35 based materials.

[0005] The use of cotton gauze that has been modified by oxidation to contain aldehyde, and then further modified by carboxymethylation, sulfonation or phosphorylation, has been disclosed for use in wound dressings. However, such dressings are not regenerated and contain functional groups such as carboxymethyl, sulfonyl or phosphonyl, that are acidic.

40 [0006] To date, aldehyde-modified, regenerated polysaccharides have not been utilized in wound dressings. Methods of producing highly oxidized tricarboxylic acid derivatives of cellulose as hemostic materials, involving two-stage oxidation by successive processing with an iodine-containing compound and nitrogen oxides, has been disclosed in RU2146264 and IN159322. As disclosed in these disclosures, oxidized cellulosic materials were prepared by preliminary oxidation with metaperiodate or periodic acid to yield periodate-oxidized, dialdehyde cellulose to form the intermediate for forming OC. The dialdehyde cellulose intermediate then is further oxidized by NO<sub>2</sub> to yield the OC with a  
 45 higher carboxylic acid content, which is suitable for use as a hemostatic, anti-microbial and wound healing agent. The disclosures do not, however, suggest or disclose that the periodate-oxidized, dialdehyde cellulose intermediate formed in the first stage oxidation may or should be used in the preparation of wound dressings.

50 [0007] It would be an advantage to provide wound dressings that are anti-microbial, that aid in covering and protecting a wound, that are compatible with acid-sensitive species and that preferably are essentially free of unnecessary or undesirable reactive moieties.

**SUMMARY OF THE INVENTION**

55 [0008] The present invention is directed to wound dressings that include a substrate for contacting a wound, which substrate comprises a wound-contacting surface, and which substrate comprises and is fabricated at least in part from a biocompatible, aldehyde-modified, regenerated polysaccharide. The aldehyde-modified, regenerated polysaccharide preferably comprises an amount of aldehyde moieties effective to render the substrate biodegradable. The wound

dressings cover and provide protection to a wound. The invention also is directed to methods of covering and providing protection to a wound, which method includes applying to a wound the wound dressing described herein.

#### DETAILED DESCRIPTION OF THE INVENTION

[0009] The present invention is directed to wound dressings that provide coverage and protection when applied to a wound. Certain dressings of the present invention may provide effective hemostasis in addition to providing coverage and protection of the wound. Effective hemostasis, as used herein, is the ability to control and/or abate capillary, venous, or arteriole bleeding within an effective time, as recognized by those skilled in the art of hemostasis.

[0010] Certain of the wound dressings of the present invention are particularly useful when conventional procedures to control and/or abate bleeding, such as pressure or suturing, are either ineffective or impractical. Such wound dressings also are useful where one desires to utilize in, or in conjunction with, the wound dressing hemostatic agents, or other biological or therapeutic compounds, moieties or species, particularly those "acid-sensitive" agents that may be degraded or denatured by, or otherwise detrimentally affected by acidic pH provided by, e.g. carboxylic acid moieties, such as is provided by conventional hemostats.

[0011] The wound dressings may take various physical forms and may include, without limitation, fibrous or non-fibrous, woven or non-woven dressings. In preferred embodiments, the wound dressing may comprise a fiber, including microfibers, a film, a fabric, a foam, a bead, a gel, or combinations thereof. Regardless of the form of the wound dressing, it will comprise a substrate for contacting and/or covering the wound.

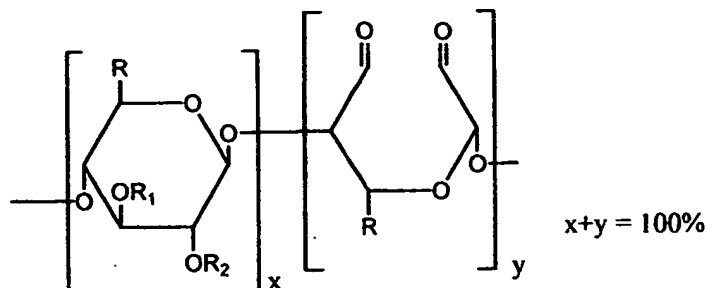
[0012] In certain embodiments, substrates may be incorporated into slurries, pastes, dispersions or other mixtures and applied directly to a wound surface. In such instances, additional wound dressings may be applied over such substrates, but are not necessarily required. In some embodiments, the wound dressing could comprise the substrate in a carrier for delivery of the substrate to the wound. For example, polymeric beads, microfibers, or ground foam substrates, all comprising the aldehyde-modified polysaccharides of the present invention, may be dispersed in slurries or dispersions that may be applied directly to a wound or, in certain circumstances, injected subcutaneously or otherwise disposed internally into the body. Gels also may be formulated so as to be applied to a wound or otherwise disposed within the body in order to provide protection of the wound.

[0013] In certain wound dressings, the dressing may consist essentially of the substrate, or may consist of the substrate. This is particularly true where the wound dressing is fabricated from a knitted, woven or non-woven hemostatic fabric that has been oxidized to provide aldehyde modification, as described herein, and which serves as the substrate for the wound dressing. In those cases, while the wound dressing may further include such components as backing layers, adhesive layers, or the like, the wound dressing can include only the hemostatic fabric.

[0014] The wound dressing substrate will comprise a wound-contacting surface. Such substrates may take various physical forms, including, but not limited to, fibrous or non-fibrous, woven or non-woven substrates. In certain embodiments, the wound dressing substrates may comprise a fiber, including microfibers, a film, a fabric, a foam, a bead, a gel, or combinations thereof. In preferred embodiments, the substrate comprises a woven fabric. The fabric may be formed, cut or otherwise shaped to cover the wound surface, thereby providing coverage and protection of the wound.

[0015] Wound dressings of the present invention, and more particularly the wound-contacting substrates thereof, comprise a biocompatible, aldehyde-modified, regenerated polysaccharide. In preferred wound dressings, the regenerated polysaccharide will contain an amount of aldehyde moieties effective to render the modified polysaccharide biodegradable, meaning that the polysaccharide is degradable by the body into components that either are resorbable by the body, or that can be passed readily by the body. More particularly, the biodegraded components do not elicit permanent chronic foreign body reaction because they are absorbed by the body, such that no permanent trace or residual of the component is retained at the implantation site.

[0016] Aldehyde-modified, regenerated polysaccharides used in the present invention may be prepared from biocompatible polysaccharides that are useful in medical devices. Such polysaccharides include, without limitation, cellulose, alkyl cellulose, e.g. methylcellulose, alkyl(hydroxyalkyl) cellulose, hydroxyalkyl cellulose, cellulose sulfate, salts of carboxymethyl cellulose, carboxymethyl cellulose, carboxyethyl cellulose, chitin, carboxymethyl chitin, hyaluronic acid, salts of hyaluronic acid, alginate, alginic acid, propylene glycol alginate, glycogen, dextran, dextran sulfate, curdlan, pectin, pullulan, xanthan, chondroitin, chondroitin sulfates, carboxymethyl dextran, carboxymethyl chitosan, chitosan, heparin, heparin sulfate, heparan, heparan sulfate, dermatan sulfate, keratan sulfate, carrageenans, chitosan, starch, amylose, amylopectin, poly-N-glucosamine, polymannuronic acid, polyglucuronic acid, polyglucuronic acid, and derivatives of any of the above. In preferred embodiments, the regenerated polysaccharide is oxidized as described herein to assure that the aldehyde-modified, regenerated polysaccharide is biodegradable. Such biodegradable, aldehyde-modified, regenerated polysaccharides may be represented by Structure I below.

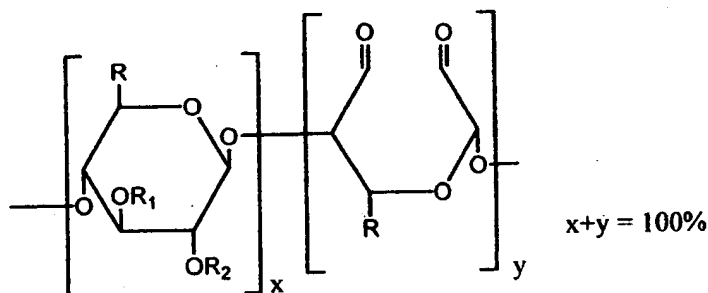


where  $x$  and  $y$  represent mole percent,  $x$  plus  $y$  equals 100 percent,  $x$  is from about 95 to about 5,  $y$  is from about 5 to about 95; and

$R$  may be  $\text{CH}_2\text{OR}_3$ ,  $\text{COOR}_4$ , sulphonic acid, or phosphonic acid;  $R_3$  and  $R_4$  may be H, alkyl aryl, alkoxy or aryloxy, and  $R_1$  and  $R_2$  may be H, alkyl, aryl, alkoxy, aryloxy, sulphonyl or phosphoryl.

[0017] In preferred embodiments of the present invention, the biocompatible, biodegradable wound dressing comprises a wound contacting/covering substrate prepared from a biocompatible, biodegradable, aldehyde-modified regenerated cellulose. Regenerated cellulose is preferred due to its higher degree of uniformity versus cellulose that has not been regenerated. Regenerated cellulose is described in, for instance, United States Patent 3,364,200, the contents of which is hereby incorporated by reference as if set forth in its entirety.

[0018] In particular, preferred aldehyde-modified regenerated cellulose is one comprising repeating units of Structure II:



where  $x$  and  $y$  represent mole percent,  $x$  plus  $y$  equals 100 percent,  $x$  is from about 95 to about 5,  $y$  is from about 5 to about 95; and  $R$  is  $\text{CH}_2\text{OH}$ ,  $R_1$  and  $R_2$  are H.

[0019] In certain embodiments according to the present invention,  $x$  is from about 90 to 10 and  $y$  is about 10 to about 90. Preferably,  $x$  is from about 80 to 20 and  $y$  is from about 20 to about 80. Even more preferably,  $x$  is from about 70 to about 30. Most preferably,  $x$  is about 70 and  $y$  is about 30.

[0020] The dressings of the present invention also provide anti-microbial activities due to the presence of effective amounts of the aldehyde moieties. It has been shown that in spite of being non-acidic, the aldehyde-modified, regenerated cellulose is anti-microbial in nature. The dressings of the present invention were found to be significantly effective against microorganisms, such as Methicillin-resistant *Staphylococcus aureus* (MRSA) and *Pseudomonas aeruginosa*, etc. The anti-microbial activities of the non-acidic aldehyde-modified, regenerated cellulose are shown to be comparable to those of the acidic carboxylic oxidized regenerated cellulose conventionally used in wound dressings. The acidic carboxylic oxidized regenerated cellulose loses its anti-microbial activities upon neutralization reaction or over a period of time as the acid groups are neutralized in the body. However, the aldehyde-modified, regenerated cellulose utilized in the present invention is expected to retain its anti-microbial activity over a longer period of time.

[0021] In preferred embodiments of the invention, the aldehyde-modified, regenerated polysaccharide is essentially free of functional or reactive moieties other than aldehyde moieties. By essentially free, it is meant that the polysaccharide does not contain such functional or reactive moieties in amounts effective to alter the properties of the aldehyde-modified, regenerated polysaccharide or to provide the substrate comprising the polysaccharide with a pH of less than about 4.5, more preferably less than about 5, or greater than about 9, preferably about 9.5. Such moieties include, without limitation, carboxylic acid moieties typically present on wound dressings made from OC. Excess levels of carboxylic acid moieties will lower the pH of the substrates and dressings so that they are not compatible for use with those species that may be degraded or denatured by such a low pH, e.g. thrombin. Other undesired moieties include, without limitation, sulfonyl or phosphonyl moieties.

[0022] The hemostat of the present invention exhibits increased thermal stability compared to that of the carboxylic oxidized regenerated cellulose fabric (ORC). The increased thermal stability may be indicative of improved physical shelf-life, compared to ORC or neutralized ORC.

[0023] In certain embodiments of the invention, the fabrics utilized in the present invention may be knitted, woven, or non-woven, provided that the fabric possesses the physical properties adequate for wound dressings. Fabrics oxidized by periodic acid or its salts described in the present invention are expected to retain physical properties and mechanical integrity required for use in wound dressings. Fabrics that are useful in the present invention include those described in United States Patent Numbers 2,773,000, 3,364,200 and 4,626,253, the contents each of which is hereby incorporated by reference herein as if set forth in its entirety. Also useful in wound dressings of the present invention are fabrics useful in adhesion prevention such as those described in United States Patent No. 5,002,551, the contents of which is hereby incorporated by reference herein as if set forth in its entirety.

[0024] In certain embodiments of the invention, the wound dressing of the present invention comprises as the wound contacting/covering substrate a warp knitted tricot fabric constructed of bright rayon yarn that has been oxidized by periodic acid or its salts such that the substrate comprises aldehyde moieties. Both Scanning Electron Microscopic (SEM) images and fabric mechanical properties indicate that the physical characteristics (density, thickness) and physical performance, e.g. fabric tensile strength and mullen burst strength, of the aldehyde-modified, regenerated cellulose in the present invention are comparable to those of the fabric disclosed in United States Patent 4,626,253.

[0025] The wound dressing of the present invention remains very flexible, conforms to a wound site, and retains good tensile and compressive strength to withstand handling during application. The aldehyde-modified, regenerated cellulose substrate can be cut into different sizes and shapes to fit the surgical needs. It can be rolled up or packed into irregular anatomic areas.

[0026] Other warp knit tricot fabric constructions which produce equivalent physical properties may, of course, be utilized in the manufacture of the aldehyde-modified, regenerated cellulose hemostatic wound dressings of the present invention, and such constructions will be apparent to those skilled in the art once having the benefit of this disclosure.

[0027] In certain embodiments of the invention, a biologics, a drug, or a combination of pharmaceutical agents, including those that otherwise may be sensitive to the low pH of conventional OC-containing wound dressings, may be incorporated into certain wound dressings of the present invention without having to adjust pH prior to incorporation into the dressing. To fabricate such a wound dressing, a drug or agent first may be dissolved in an appropriate solvent. The fabric is then coated with the drug solution and the solvent is removed. Preferred biologics, drugs and agent include analgesics, anti-infective agents, antibiotics, adhesion preventive agents, pro-coagulants, and wound healing growth factors. The aldehyde groups formed on the polysaccharide matrix during the periodate oxidation reaction can be used to covalently bond amine containing biologics and therapeutic agents. The combination of such biologics, drugs and agents with wound dressings of the present invention using the aldehyde-modified regenerated cellulose substrates can provide improved hemostatic wound dressings, wound healing dressings, drug delivery devices, and tissue engineering matrices.

[0028] While the following examples demonstrate certain embodiments of the invention, they are not to be interpreted as limiting the scope of the invention, but rather as contributing to a complete description of the invention.

#### Example 1:

Preparation of woven aldehyde-modified regenerated cellulose fabric:

[0029] A 15.75 g piece of Nu-Knit® rayon fabric was cut in the form of a strip 1.5 inches wide. The strip was wound on a mandrel and suspended in 600 ml of aqueous isopropyl alcohol (IPA) (200 ml IPA/400 ml de-ionized (DI) water). 20.8 g of sodium periodate (Aldrich, Milwaukee, 53201) was dissolved in the solution (1:1 molar ratio) and the mandrel was rotated at moderate rpm in the solution for 21 hours at ambient temperature. It is essential that the oxidation of the fabric be conducted in the dark. The solution pH was 3.8. The solution was discarded after the reaction. The mandrel with the oxidized fabric was washed for 30 minutes in 1 liter of cold DI water containing 50 ml of ethylene glycol. It was then washed with aqueous IPA (50/50) for 15 minutes, followed by a pure IPA wash for 15 minutes. The fabric was

dried in ambient air for several hours.

[Aldehyde content: Ave. 22.83%]

[0030] The oxidized fabric then was evaluated for hemostasis as set forth below. Results are provided in Table 1.

#### 5 Example 2:

Preparation of non-woven aldehyde-modified cellulose fabric:

10 [0031] A 10 g piece of cellulose rayon non-woven fabric was cut in the form of a rectangle and placed in an aqueous solution of sodium periodate (Aldrich, Milwaukee, 53201) (1:0.7 molar ratio). The fabric was placed in a container modified to exclude light and soaked in the dark for 24 hours at 37°C. The solution was discarded after the reaction. The fabric was repeatedly washed with DI water until the pH was 6-7. It was then washed with aqueous IPA (50/50) for 15 minutes. The fabric then was washed in pure IPA for 15 minutes. The fabric was dried in ambient air for several hours. [aldehyde content: 51.04%]

15 [0032] The oxidized fabric then was evaluated for hemostasis as set forth below. Results are provided in Table 1.

#### Example 3:

Preparation of aldehyde-modified regenerated cellulose Powders:

20 [0033] 10.6 g of powdered cellulose rayon was suspended in an aqueous solution of sodium periodate (Aldrich, Milwaukee, 53201) (13.9 g in 250 ml DI water) and stirred for 7 hours at ambient temperature in the dark. The solution was filtered after the reaction. The filtrate was repeatedly washed with DI water until the pH was in the range of from 6 to 7. It was then washed with aqueous IPA (50/50) and pure IPA for 15 min each. The powder was dried in air for several hours. [aldehyde content: 32.8 %]

25 [0034] The oxidized powder then was evaluated for hemostasis as set forth below. Results are provided in Table 1.

#### Example 4:

30 Preparation of aldehyde-modified cellulose beads:

[0035] 13.67 g of porous cellulose beads are floated in an aqueous solution of sodium periodate (Aldrich, Milwaukee, 53201) (18g in 250 ml DI water/125ml IPA) and stirred for 24 hours at ambient temperature. The material was filtered and the filtrate (beads and crushed beads) was repeatedly washed with DI water until the pH was in the range of from 6 to 7. It was then washed with aqueous IPA (50/50) and pure IPA for 15 min each. The material was dried in air for several hours. [aldehyde content: intact beads-29.86 %; crushed beads-35%]

35 [0036] The oxidized beads then were evaluated for hemostasis as set forth below. Results are provided in Table 1.

#### Example 5:

40 Preparation of water-soluble aldehyde-modified methylcellulose:

[0037] 100 g of a 5% methylcellulose (Aldrich, Milwaukee, 53201) aqueous solution was combined with 3 g of periodic acid (Aldrich, Milwaukee, 53201) and was then stirred for 5 hours at ambient temperature in the dark. 1.5 ml of ethylene glycol was added to the reaction solution and stirred for 30 minutes. 2000 ml of acetone were added slowly into the reaction solution to precipitate the methylcellulose dialdehyde. The reaction mixture was allowed to stand for 20-30 minutes to separate the liquid phase from the solid phase. The supernatant then was removed and the solid phase centrifuged to precipitate the solids. The solid precipitate was dissolved in 100 ml DI over night followed by dialysis for 72 hours. The final wet mixture was lyophilized to form a sponge/foam.

50 [0038] The material then was evaluated for hemostasis as set forth below. Results are provided in Table 1.

#### Example 6:

Preparation of water-soluble aldehyde-modified sodium carboxymethyl cellulose:

55 [0039] 100 g of a 4% sodium carboxymethyl cellulose (Aldrich, Milwaukee, 53201) aqueous solution was added with 2.12 g of sodium periodate (Aldrich, Milwaukee, 53201) and was then stirred for 24 hours at 4°C in the refrigerator. 200 ml ethanol was slowly added into the reaction solution to precipitate the aldehyde-modified carboxymethyl cellulose.

lose. The supernatant was removed and the solid phase mixture centrifuged to precipitate the solids. The solid precipitate was dissolved in 100 ml DI. Precipitation and centrifuging were repeated. The final product was dissolved in 100 ml DI then lyophilized to form a sponge/foam.

[0040] The material then was evaluated for hemostasis as set forth below. Results are provided in Table 1.

Table 1

Sample	Time to Hemostasis (seconds)
Example 1 fabric	187 (n=11)
Example 2	96 (n=5)
Example 3	120 (n=3)
Example 4	238 (n=1)
Example 5	120 (n=2)
Example 6	360 (n=2)
Surgical gauze	>720 (n=6)

#### Example 7:

Hemostatic evaluation of dressings in porcine splenic incision model:

[0041] A porcine spleen incision model was used for hemostasis evaluation. The materials were cut into 2.5 cm X 2.0 cm rectangles. A linear incision of 1.5 cm with a depth of 1.0 cm was made with a surgical blade on a porcine spleen. After application of the test article, digital tamponade was applied to the incision for 2 minutes. The hemostasis was then evaluated. Additional applications of digital tamponade for 30 seconds each were used until complete hemostasis was achieved. The fabrics providing hemostasis within 15 minutes, preferably within 12 minutes, were considered to be effective hemostats. Wound dressings comprising aldehyde-modified regenerated cellulose achieved rapid hemostasis compared to the negative control of surgical gauze.

#### Example 8:

Characterization of Aldehyde Content of aldehyde modified regenerated cellulose

[0042] 1 g of fabric was digested in 10 ml of 0.5N NaOH and 100 ml DI water at ambient temperature for 2 hours. The residual NaOH was back-titrated to a fixed endpoint using 0.1N HCl. The aldehyde content was calculated using the formula:

$$\% \text{ Aldehyde Content} = [(B-S) \cdot 0.81] / W$$

where B is the burette reading (in ml) from a blank titration, S is the burette reading (in ml) from a sample and W is the sample weight. Aldehyde content is the number of glucose rings (by mole) containing the dialdehyde functionality.

[0043] Aldehyde content of aldehyde modified regenerated cellulose in the present invention, processed in various physical forms, is substantially consistent in the range of 20-50%.

#### Example 9:

Effects of aldehyde-modified regenerated cellulose and ORC absorbable hemostat on Methicillin-resistant *Staphylococcus aureus* (MRSA)

[0044] Studies were designed to study the effect of the sample against the microbial challenge over a period of time. Aldehyde-modified regenerated cellulose fabric (Example 1), Surgical NU-KNIT® and Surgical Fibrillar® samples were cut to a weight of 165-mg (+/- 2-mg). The weighed sample was then placed into a sterile test tube. An aliquot of 11-ml of TSB was added to the test tube containing the sample. Three (3) test tubes were prepared for each aldehyde-modified regenerated cellulose powder and control sample. Each test tube was inoculated with 0.1-μL of microorganism from stock cultures. Prepared samples were subsequently diluted and pour plated. This procedure was carried

out at time 0 (immediately following inoculation), 1, 6, 24, and 48 hours after inoculation.

[0045] Methicillin-resistant *Staphylococcus aureus* (MRSA) organisms were grown in Trypticase Soy Broth (TSB) for 24 hours at 30-35°C. Trypticase Soy Agar (TSA) and TSB were the media used in this study. The dilutions used 0.85% saline. All media and solutions were sterile.

[0046] The experiment results demonstrate that periodate oxidized regenerated cellulose hemostats (Example 1 fabric) and the Surgicel Nu-Knit® controls were both effective at significantly reducing the microbial populations of MRSA.

## Claims

### 1. A wound dressing, comprising:

a substrate for contacting a wound, said substrate comprising;  
a wound-contacting surface; and  
a biocompatible, aldehyde-modified, regenerated polysaccharide.

2. The wound dressing of claim 1 wherein said substrate comprises a fiber, a fabric, a sponge, a foam, a film, a bead, a gel, or combinations thereof.

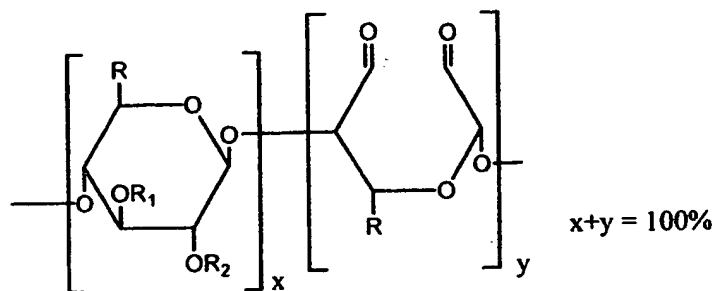
3. The wound dressing of claim 1 wherein said aldehyde-modified, regenerated polysaccharide is selected from the group consisting of aldehyde-modified, regenerated cellulose, alkylcellulose, alkylhydroxyalkyl cellulose, hydroxy-alkyl cellulose, cellulose sulfate, salts of carboxymethyl cellulose, carboxymethyl cellulose, carboxyethyl cellulose, chitin, carboxymethyl chitin, hyaluronic acid, salts of hyaluronic acid, alginate, alginic acid, propylene glycol alginate, glycogen, dextran, dextran sulfate, curdlan, pectin, pullulan, xanthan, chondroitin, chondroitin sulfates, carboxymethyl dextran, carboxymethyl chitosan, chitosan, heparin, heparin sulfate, heparan, heparan sulfate, dermatan sulfate, keratan sulfate, carrageenans, chitosan, starch, amylose, amylopectin, poly-N-glucosamine, poly-mannuronic acid, polyglucuronic acid, polyguluronic acid and derivatives of any of the above.

4. The wound dressing of claim 3 wherein said aldehyde-modified, regenerated polysaccharide comprises an amount of aldehyde moieties effective to render the substrate biodegradable.

5. The wound dressing of claim 4 wherein said aldehyde-modified, regenerated polysaccharide comprises regenerated cellulose.

6. The wound dressing of claim 5 wherein said substrate comprises a fabric.

7. The wound dressing of claim 6 wherein said regenerated cellulose comprises repeating units of structure II:



where x and y represent mole percent, x plus y equals 100 percent, x is from about 95 to about 5, y is from about 5 to about 95; and R is  $\text{CH}_2\text{OH}$ ,  $\text{R}_1$  and  $\text{R}_2$  are H.

8. The wound dressing of claim 7 wherein x is from about 80 to about 20 and y is from about 20 to about 80.



9. The wound dressing of claim 1 wherein said aldehyde-modified, regenerated polysaccharide is essentially free of carboxylic acid, sulfonyl and phosphonyl moieties.

10. The wound dressing of claim 5 wherein said aldehyde-modified, regenerated polysaccharide is essentially free of carboxylic acid, sulfonyl and phosphonyl moieties.

11. A method of providing protection to a wound, comprising:

applying to said wound a wound dressing, said wound dressing comprising a substrate which comprises:

a wound-contacting surface; and  
a biocompatible, aldehyde-modified, regenerated polysaccharide.

12. The method of claim 11 wherein said substrate comprises a fiber, a fabric, a sponge, a foam, a film, a bead, a gel, or combinations thereof.

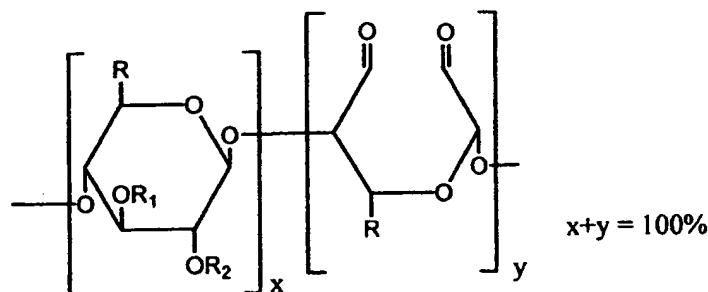
13. The method of claim 11 wherein said aldehyde-modified, regenerated polysaccharide is selected from the group consisting of aldehyde-modified, regenerated cellulose, alkylcellulose, alkylhydroxyalkyl cellulose, hydroxyalkyl cellulose, cellulose sulfate, salts of carboxymethyl cellulose, carboxymethyl cellulose, carboxyethyl cellulose, chitin, carboxymethyl chitin, hyaluronic acid, salts of hyaluronic acid, alginate, alginic acid, propylene glycol alginate, glycogen, dextran, dextran sulfate, curdlan, pectin, pullulan, xanthan, chondroitin, chondroitin sulfates, carboxymethyl dextran, carboxymethyl chitosan, chitosan, heparin, heparin sulfate, heparan, heparan sulfate, dermatan sulfate, keratan sulfate, carrageenans, chitosan, starch, amylose, amylopectin, poly-N-glucosamine, polymannuronic acid, polyglucuronic acid, polyguluronic acid and derivatives of any of the above.

14. The method of claim 13 wherein said aldehyde-modified, regenerated polysaccharide comprises an amount of aldehyde moieties effective to render the substrate biodegradable.

15. The method of claim 14 wherein said aldehyde-modified, regenerated polysaccharide comprises aldehyde-modified, regenerated cellulose.

16. The method of claim 15 wherein said substrate comprises a fabric.

17. The method of claim 16 wherein said aldehyde-modified, regenerated cellulose comprises repeating units of structure II,



where x and y represent mole percent, x plus y equals 100 percent, x is from about 95 to about 5, y is from about 5 to about 95; and R is  $\text{CH}_2\text{OH}$ ,  $\text{R}_1$  and  $\text{R}_2$  are H.

18. The method of claim 11 wherein said aldehyde-modified, regenerated cellulose is essentially free of carboxylic acid, sulfonyl and phosphonyl moieties.



European Patent  
Office

# PARTIAL EUROPEAN SEARCH REPORT

Application Number

which under Rule 45 of the European Patent Convention EP 03 25 4095 shall be considered, for the purposes of subsequent proceedings, as the European search report

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
P,X	WO 03 020191 A (UNIV IOWA RES FOUND ; KUMAR VIJAY (US)) 13 March 2003 (2003-03-13) * page 3, line 23 - page 4, line 8 * * page 6, line 29 - page 8, line 6 * * page 9, line 18 - line 27 * * page 15, line 11 - page 16, line 3; claims 1,7,14,21,22; figure 2 *	1-18	A61L15/28
X	US 2002/012693 A1 (DIEGELMANN ROBERT F ET AL) 31 January 2002 (2002-01-31) * paragraph [0004] * * paragraph [0041] - paragraph [0047] * * paragraph [0133] - paragraph [0151] * * paragraph [0175] * * claims 1,3,6; figure 3 *	1-18	
X	WO 98 33479 A (SANTAR IVAN ; KISS FRANTISEK (CZ); BRIESTENSKY JIRI (CZ); ALLTRADE) 6 August 1998 (1998-08-06) * page 2, line 28 - page 3, line 11 * * page 4, line 19 - line 26 * * page 17, line 1 - line 2 * * claims 1,41,47,48,56 *	1-18	
			TECHNICAL FIELDS SEARCHED (Int.Cl.7)
			A61L
<p style="text-align: center;">-/--</p>			
<b>INCOMPLETE SEARCH</b> <p>The Search Division considers that the present application, or one or more of its claims, does not comply with the EPC to such an extent that a meaningful search into the state of the art cannot be carried out, or can only be carried out partially, for these claims.</p> <p>Claims searched completely :</p> <p>Claims searched incompletely :</p> <p>Claims not searched :</p> <p>Reason for the limitation of the search:</p> <p style="text-align: center;">see sheet C</p>			
Place of search		Date of completion of the search	Examiner
MUNICH		16 January 2004	Ganschow, S
<b>CATEGORY OF CITED DOCUMENTS</b> <p>X : particularly relevant if taken alone  Y : particularly relevant if combined with another document of the same category  A : technological background  O : non-written disclosure  P : intermediate document</p> <p>T : theory or principle underlying the invention  E : earlier patent document, but published on, or after the filing date  D : document cited in the application  L : document cited for other reasons  &amp; : member of the same patent family, corresponding document</p>			

EPO FORM 1503 03.02 (P04007)



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INCOMPLETE SEARCH  
SHEET C

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Although claims 11-18 are directed to a method of treatment of the human/animal body (Article 52(4) EPC), the search has been carried out and based on the product applied to the wound (see claims 1-10).

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Claim(s) searched completely:  
1-10

Claim(s) searched incompletely:  
11-18

Reason for the limitation of the search (non-patentable invention(s)):

Article 52 (4) EPC - Method for treatment of the human or animal body by therapy

## PARTIAL EUROPEAN SEARCH REPORT

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DOCUMENTS CONSIDERED TO BE RELEVANT			CLASSIFICATION OF THE APPLICATION (Int.CL.7)
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	
X	US 3 868 955 A (SIRAGUSA JUDITH ANN ET AL) 4 March 1975 (1975-03-84) * column 2, line 14 - line 31 * * column 3, line 46 - column 5, line 57 * ---	1-18	
A	WO 98 00446 A (WATT PAUL WILLIAM ;LORIMER ELAINE (GB); DOYLE PETER JOHN (GB); JOH) 8 January 1998 (1998-01-08) * the whole document * ---		
A	GB 2 314 842 A (JOHNSON & JOHNSON MEDICAL) 14 January 1998 (1998-01-14) * the whole document * -----		
			TECHNICAL FIELDS SEARCHED (Int.CL.7)

**ANNEX TO THE EUROPEAN SEARCH REPORT  
ON EUROPEAN PATENT APPLICATION NO.**

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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on  
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

16-01-2004

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 03020191 A	13-03-2003	WO 03020191 A1	13-03-2003
		US 2003064089 A1	03-04-2003
US 2002012693 A1	31-01-2002	US 6627785 B1	30-09-2003
		US 2003206944 A1	06-11-2003
		AU 4330901 A	12-09-2001
		CA 2401582 A1	07-09-2001
		EP 1267766 A2	02-01-2003
		WO 0164132 A2	07-09-2001
		US 2002064551 A1	30-05-2002
WO 9833479 A	06-08-1998	AU 725625 B2	19-10-2000
		AU 6004298 A	25-08-1998
		EP 0973504 A1	26-01-2000
		GB 2337201 A ,B	17-11-1999
		IE 980057 A1	15-11-2000
		WO 9833479 A1	06-08-1998
		JP 2001509801 T	24-07-2001
		US 6372196 B1	16-04-2002
		ZA 9800784 A	19-08-1998
US 3868955 A	04-03-1975	AT 338980 B	26-09-1977
		BE 824345 A1	14-07-1975
		DE 2500162 A1	08-07-1976
		FR 2297636 A1	13-08-1976
		GB 1477571 A	22-06-1977
		LU 71650 A1	24-06-1975
		NL 7500428 A ,B,	16-07-1976
WO 9800446 A	08-01-1998	GB 2314840 A	14-01-1998
		AT 195742 T	15-09-2000
		AU 725296 B2	12-10-2000
		AU 3269397 A	21-01-1998
		BR 9710003 A	11-01-2000
		CA 2258849 A1	08-01-1998
		CZ 9804274 A3	12-05-1999
		DE 69702911 D1	28-09-2000
		DE 69702911 T2	22-02-2001
		EP 0907664 A1	14-04-1999
		ES 2148991 T3	16-10-2000
		WO 9800446 A1	08-01-1998
		GR 3034853 T3	28-02-2001
		HU 9903404 A2	28-03-2000
		JP 2000514110 T	24-10-2000
		KR 2000022286 A	25-04-2000
		PL 330825 A1	07-06-1999

EPO FORM P459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

**ANNEX TO THE EUROPEAN SEARCH REPORT  
ON EUROPEAN PATENT APPLICATION NO.**

EP 03 25 4995

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on  
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

16-01-2004

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
WO 9800446	A		PT 907664 T	29-12-2000
-----				
GB 2314842	A	14-01-1998	AT 247493 T	15-09-2003
			AU 737809 B2	30-08-2001
			AU 3269297 A	21-01-1998
			BR 9710177 A	18-01-2000
			CA 2258990 A1	08-01-1998
			CZ 9804251 A3	12-05-1999
			DE 69724257 D1	25-09-2003
			EP 1325754 A1	09-07-2003
			EP 0918548 A1	02-06-1999
			WO 9800180 A1	08-01-1998
			JP 2000513258 T	10-10-2000
			KR 2000022287 A	25-04-2000
			PL 330824 A1	07-06-1999
-----				

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82